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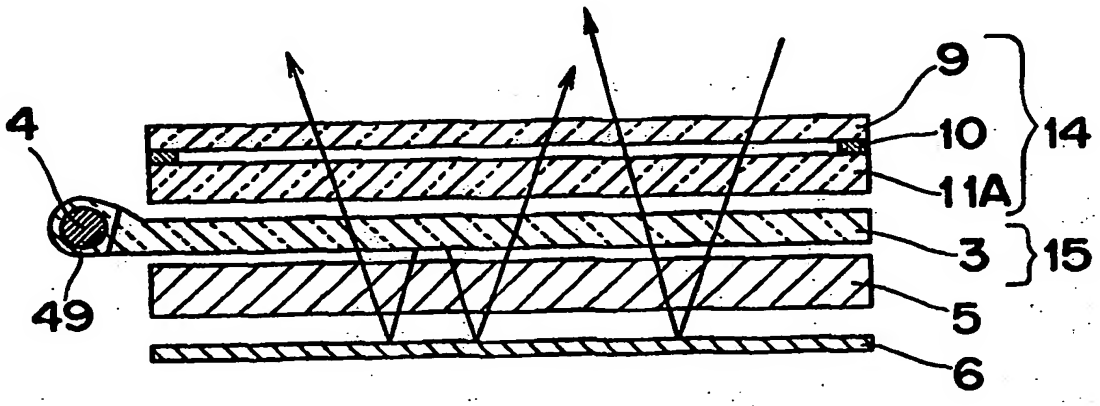


(57) Abstract

A reflecting type liquid crystal display (5), a front light unit (15) including a transparent 0.3–2.0 mm thick light guide plate (3) and a light source (4) set at an end face of the light guide plate, and a transparent touch panel (14) are sequentially layered on a reflecting plate (6).

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# TOUCH WITH FRONT LIGHTING

## Technical Field

The present invention relates to a front light-combined touch panel device having a front light for illumination of a liquid crystal display integrally combined with a touch panel (touch-sensitive panel). The front light-combined touch panel device according to the present invention is particularly fit for use in portable electronic apparatuses with a reflecting type liquid crystal display, e.g., cordless telephones, portable telephones, scientific calculators, subnotebook personal computers, PDAs (Personal Digital Assistants), digital cameras, video cameras, business-application communication instruments, etc.

## Background Art

Compact and light-weight portable electronic devices with a liquid crystal display part have been developed and introduced commercially. A light transmission type liquid crystal display used at the liquid crystal display part needs a back light, which is driven by a dry cell, a charge cell or the like battery in the case of portable electronic apparatuses. Particularly, a color display required of subnotebook personal computers, PDAs,

digital cameras needs the back light using a cold cathode fluorescent tube of high luminance as a light source, thereby consuming a large quantity of power at the back light eventually to remarkably, decrease a drive time of the battery.

As such, studies have been made to use a liquid crystal display of a reflecting type not requiring the back light for portable electronic devices to reduce consumption power. The liquid crystal display of the type is now being brought into the commercial stage. Without using the back light, the reflecting type liquid crystal display consumes less power. In addition, the reflecting type liquid crystal display exerts superior visibility even under external light when used outdoors. From these points of view, therefore, the reflecting type liquid crystal display is suitable for use in portable electronic devices.

However, in using the reflecting type liquid crystal display in an environment where a sufficient quantity of external light is not secured, for instance, indoors or at night, it becomes necessary to illuminate the reflecting type liquid crystal display from the front side, leading to a proposal for an illumination device (front light unit) having a light source positioned above the reflecting type liquid crystal display.

According to an example of the proposal, the

illumination device is mounted to a lid part or a storageable strut of the reflecting type liquid crystal display. In the illumination device of another type, the light source such as a cold cathode fluorescent tube, a light bulb, or an LED is adapted to directly illuminate the reflecting type liquid crystal display. In a different illumination device, a resin plate or film having light diffusive properties, or a resin plate or film having light condensing properties is arranged in front of the light source to indirectly illuminate the reflecting type liquid crystal display.

In the case where the illumination device has its light-emitting body fitted to the lid part of the reflecting type liquid crystal display, the lid is made thick, with hindering portability of the portable electronic device. The lid of the reflecting type liquid crystal display is originally designed to protect the reflecting type liquid crystal display against impacts from outside, and therefore it is not preferable to dispose the light-emitting body fragile to shocks at the lid part.

On the other hand, the illumination device mounted to the strut probably breaks the strut or light source as a result of careless handling when in use and is complicated in constitution because of the necessity for an accommodation mechanism to accommodate the strut when not

in use.

Disclosure Of Invention

The present invention is devised to solve the above-described inconveniences and has for its object to provide a front light-combined touch panel device which can illuminate a reflecting type liquid crystal display uniformly without damaging portability of a portable electronic apparatus.

In accomplishing these and other aspects, according to a first aspect of the present invention, there is provided a front light-combined touch panel device comprising: a reflecting type liquid crystal display; a front light unit including a transparent light guide plate and a light source set at an end face of the light guide plate; and a transparent touch panel, which are sequentially layered on a reflecting plate.

According to a second aspect of the present invention, there is provided a front light-combined touch panel device according to the first aspect, wherein the transparent touch panel is a transparent touch panel of a resistive model, with having an upper part of the front light unit bonded to a lower part of the transparent touch panel via a transparent resin layer.

According to a third aspect of the present invention, there is provided a front light-combined touch

panel device according to the first aspect, wherein the transparent touch panel is a transparent touch panel of a film type of a resistive model, with having an upper part of the front light unit bonded to a lower part of the transparent touch panel via a transparent resin layer.

According to a fourth aspect of the present invention, there is provided a front light-combined touch panel device according to any one of the first through third aspects, wherein the light guide plate has a minute polygonal or circular dot gradation pattern formed at least at one face thereof of a dot size of 200μm or smaller and an area ratio of 60% or smaller with the use of an ink having, as a most ingredient, a transparent or semitransparent resin of a higher index of refraction than the light guide plate.

According to a fifth aspect of the present invention, there is provided a front light-combined touch panel device according to the fourth aspect, wherein the light guide plate has the dot gradation pattern formed with the use of an ink having, as a most ingredient, a transparent or semitransparent resin of a higher index of refraction than the light guide plate and including a light diffusible pigment.

According to a sixth aspect of the present invention, there is provided a front light-combined touch

panel device according to any one of the first through third aspects, wherein the light guide plate is constituted of a transparent or semitransparent resin layer of a higher index of refraction than the light guide plate at least at one face thereof.

According to a seventh aspect of the present invention, there is provided a front light-combined touch panel device according to any one of the first through sixth aspects, wherein the light guide plate has a fine grained pattern formed at least at one face thereof.

According to an eighth aspect of the present invention, there is provided a front light-combined touch panel device according to any one of the first through sixth aspects, wherein the light guide plate has a plurality of prisms formed at least at one face thereof at the side of the reflecting type liquid crystal display with a pitch of 30-500μm and a breadth of 30-100μm in parallel to an incident end face thereof.

According to a ninth aspect of the present invention, there is provided a front light-combined transparent touch panel device according to any one of the first through eighth aspects,

wherein the transparent touch panel comprises: an upper electrode sheet having an upper electrode formed on a lower face of a film-like insulating substrate; and a lower

electrode sheet having a lower electrode formed on an upper face of a plate-like or film-like insulating substrate with minute projections and dips arranged on the upper face thereof, in which the upper electrode sheet and the lower electrode sheet are arranged to face each other via an air layer between the electrodes, and

wherein the light guide plate bonded to a rear face of the transparent touch panel via a transparent resin layer, and the transparent touch panel and the front light unit are combined in one body.

According to a tenth aspect of the present invention, there is provided a front light-combined transparent touch panel device according to the ninth aspect, wherein a dent part of the minute projections and dips is constituted of many minute dips on the entire upper face of the insulating substrate.

According to an eleventh aspect of the present invention, there is provided a front light-combined transparent touch panel device according to the tenth aspect, wherein an area ratio of the minute dips distanced away from the light source is larger than an area ratio of the minute dips in a vicinity of the light source.

According to a 12th aspect of the present invention, there is provided a front light-combined transparent touch panel device according to any one of the

ninth through 11th aspects, wherein the film-like insulating substrate with the minute projections and dips has many minute projections formed by transparent minute beads incorporated in resin to be molded, before the film-like insulating substrate is molded.

According to a 13th aspect of the present invention, there is provided a front light-combined transparent touch panel device according to any one of the ninth through 11th aspects, wherein the projections of the minute projections and dips are formed in a coat by coating or printing of an ink including transparent minute beads.

According to a 14th aspect of the present invention, there is provided a front light-combined transparent touch panel device according to the 13th aspect, wherein the coat is formed in a dot gradation pattern having a larger area ratio at a part away from the light source than in a vicinity of the light source.

According to a 15th aspect of the present invention, there is provided a front light-combined touch panel device according to any one of the first through 14th aspects, wherein the light guide plate comprising: a flat face at a side of the touch panel; and at a side of the liquid crystal display, a flat part (33a) having a flat face at a side of the liquid crystal display and an inclined part (33b) having an inclined face at a side of

the liquid crystal display, and light entering from a side face of the light guide plate is reflected on the flat face of the flat part, inside of the light guide plate, and the light is projected outside from the inclined face of the inclined part.

According to a 16th aspect of the present invention, there is provided a front light-combined touch panel device according to the 15th aspect, wherein an angle defined between the end face where the light source of the light guide plate is disposed and a face of the light guide plate at the side of the touch panel is 88-92°, and an angle defined between the flat face of the flat part and the inclined face of the inclined part adjacent to the flat part in an opposite direction to an incident face of the light guide plate on the face at the side of the liquid crystal display is not smaller than the above angle and smaller than 180°.

According to a 17th aspect of the present invention, there is provided a front light-combined touch panel device according to any one of the first through 16th aspects, further comprising a transparent layer of a smaller index of refraction than the light guide plate is formed at the face of the light guide plate at the side of the liquid crystal display.

According to a 18th aspect of the present

invention, there is provided a front light-combined touch panel device according to any one of the first through 17th aspects, wherein the light guide plate has a 0.3-2.0mm thickness.

Brief Description Of Drawings

These and other aspects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, in which:

Fig. 1 is a sectional view of a front light-combined touch panel device according to a first embodiment of the present invention;

Fig. 2 is a perspective view of a portable electronic apparatus of a concrete example with the front light-combined touch panel device of the first embodiment incorporated therein;

Fig. 3 is a perspective view of a portable electronic apparatus of another concrete example with the front light-combined touch panel device of the first embodiment incorporated therein;

Fig. 4 is a sectional view showing the constitution in detail of the front light-combined touch panel device of the first embodiment;

Fig. 5 is a sectional view of a front light-combined touch panel device in a second embodiment of the present invention;

Fig. 6 is a sectional view of a front light-combined touch panel device in a third embodiment of the present invention;

Fig. 7 is a sectional view of a front light-combined touch panel device in a fourth embodiment of the present invention;

Fig. 8 is a sectional view of the constitution of a front light unit and the periphery used in a front light-combined touch panel device in a fifth embodiment of the present invention;

Fig. 9 is a sectional view of the constitution of a front light unit and the periphery used in a front light-combined touch panel device in a sixth embodiment of the present invention;

Fig. 10 is a sectional view of the constitution of a front light unit and the periphery used in a front light-combined touch panel device in a seventh embodiment of the present invention;

Fig. 11 is a sectional view of the constitution of a front light unit and the periphery used in a front light-combined touch panel device in an eighth embodiment of the present invention;

Fig. 12 is a sectional view of the constitution of a front light unit and the periphery used in a front light-combined touch panel device in a ninth embodiment of the present invention;

Fig. 13 is a sectional view showing the constitution of an example of a conventional front light;

Fig. 14 is a diagram explanatory of the conventional front light with a touch panel bonded thereto;

Fig. 15 is a sectional view of a front light-combined touch panel according to a tenth embodiment of the present invention;

Fig. 16 is a sectional view showing the constitution in detail of a front light-combined touch panel device of an eleventh embodiment of the present invention;

Figs. 17 and 18 are partial enlarged views showing two examples of the light guide plate of the front light-combined touch panel device of Fig. 16; and

Fig. 19 is a sectional view showing the constitution in detail of a front light-combined touch panel device of a modification of the eleventh embodiment of the present invention.

Best Mode for Carrying Out the Invention

Before the description of the present invention

proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.

Fig. 1 is a sectional view of a portable electronic apparatus 1 with a front light-combined touch panel device in a first embodiment of the present invention incorporated therein. Fig. 2 is a perspective view of a portable electronic apparatus 1A of a concrete example in which the front light-combined touch panel device of the first embodiment is incorporated. Fig. 3 is a perspective view of a portable electronic apparatus 1B of another concrete example in which the front light-combined touch panel device of the first embodiment is incorporated. Fig. 4 is a sectional view showing the constitution in detail of the front light-combined touch panel device of the first embodiment.

Figs. 5-7 are sectional views of front light-combined touch panel devices according to a second-a fourth embodiments of the present invention respectively.

Figs. 8-12 are sectional views each showing the constitution of a front light unit and the vicinity in a front light-combined touch panel device according to a fifth-a ninth embodiments of the present invention.

Fig. 15 is a sectional view showing the constitution of a front light unit and the vicinity in a

front light-combined touch panel device according to a tenth embodiment of the present invention.

Fig. 16-19 are sectional views showing the constitution of a front light unit and the vicinity in a front light-combined touch panel device according to an eleventh embodiment of the present invention.

In Figs. 1-12 and Figs. 15-19, reference numerals 1 through 15 represent respectively: 1, 1A, 1B a portable electronic apparatus; 3 a rectangular light guide plate; 4 a light source; 5 a rectangular reflecting type liquid crystal display; 6 a rectangular reflecting plate; 7 a rectangular liquid crystal display part; 8 (8A, 8B, 8C, 8D, 8E) a light diffusion layer; 9 a rectangular upper electrode plate; 10 an adhesive layer; 11, 11A, 11B a rectangular lower electrode plate; 12 a transparent resin layer; 13 a rectangular supporting body; 14 a rectangular transparent touch panel; and 15 a reflecting type liquid crystal display illumination device (front light unit).

As indicated in Fig. 1, the front light-combined touch panel device of the first embodiment has the reflecting type liquid crystal display 5, the front light unit 15 with the transparent 0.3-2.0mm thick light guide plate 3 and the light source 4 disposed at an end face of the light guide plate 3, and the transparent touch panel 14 sequentially layered on the reflecting plate 6.

The above front light-combined touch panel device is applied to the portable electronic apparatus 1 equipped with the reflecting type liquid crystal display 5 and the transparent touch panel 14, for instance, cordless telephone, portable telephone, scientific calculator, subnotebook personal computer, PDA (Personal Digital Assistant), digital camera, video camera, business-application communication instrument, etc. (with reference to Figs. 2-3).

A concrete example of the portable electronic apparatus 1 is shown in a perspective view in Fig. 2. The portable electronic apparatus 1 realizes an input function through the transparent touch panel 14 which is a pen-based input device set at an uppermost part of the display part. The portable electronic apparatus 1 of another concrete example in Fig. 3 has a keyboard 100 as the input device in addition to the transparent touch panel 14 as the input device at a display face.

The transparent touch panel 14 can be one that is called as a resistive model. The transparent touch panel 14 of the resistive model is, as is shown in, e.g., Fig. 4, constituted of a multilayer structure which comprises: the lower electrode plate 11A of an insulating substrate, for instance, a glass plate or the like where a lower electrode of a transparent conductive film and spacers of minute dots

polygonal or circular in plane are set on a surface; and the upper electrode plate 9 of an insulating substrate, e.g., a flexible film having an upper electrode of a transparent conductive film, via the dot-shaped spacers and the adhesive layer 10 in the periphery of the electrode plates. To partly press a surface of the transparent touch panel 14 from the side of an input face bends the flexible upper electrode plate 9 to bring the upper electrode in touch with the lower electrode, thereby achieving electric conduction between the electrodes thus enabling inputs. A capacitive model, an optical model, or the like is also applicable to the transparent touch panel 14.

The front light-combined touch panel device is a combination of the reflecting plate 6 reflecting external light and light from the front light unit 15, the reflecting type liquid crystal display 5, the front light unit 15 including the light guide plate 3 and the light source 4 disposed at one end part of the light guide plate 3 and, the transparent touch panel 14 (referring to Fig. 4).

In the second embodiment, the lower electrode plate 11A of the transparent touch panel 14 may be a flexible film 11B with an electrode, similar to the upper electrode plate 9 (referring to Fig. 5). This is named as a film type, which is advantageously light-weight because of the use of a flexible film in place of the glass for the

lower electrode and prevents the transparent touch panel 14 from breaking easily. In general usage, in order to provide the transparent touch panel 14 of the film type with rigidity, a transparent resin plate formed of acrylic resin, polycarbonate resin, or the like transparent resin is attached as the supporting body 13 below the lower electrode plate 11B.

In the third embodiment, the transparent touch panel 14 having the glass lower electrode plate 11A and the front light unit 15 in the constitution of Fig. 4 may be bonded via the transparent resin layer 12 of a transparent self-adhesive, a transparent gel, etc. (referring to Fig. 6).

The transparent resin layer 12 is obtained by applying a general transparent self-adhesive, for example, an acrylic ester copolymer or the like acrylic resin, urethane resin, silicone resin, or rubber resin, etc. The transparent gel is obtained by forming a transparent polymer self-adhesive to a gel sheet. Urethane series adhesives, acryl series, or natural polymer material, etc. can be used for the polymer self-adhesive. This arrangement eliminates an air layer between the transparent touch panel 14 and the front light unit 15. Due to a difference between an index of refraction of the air (1.0) and an index of refraction of glass or transparent resin

(1.4-1.7), the air layer if present between the lower electrode plate 11A or 11B and the light guide plate 3 decreases light transmittance. The arrangement with the light guide plate 3 and the transparent touch panel 14 bonded via the transparent resin layer 12 removes the intervening air layer between the light guide plate 3 and the transparent touch panel 14, thereby improving light transmittance between the light guide plate 3 and the transparent touch panel 14.

In the fourth embodiment, in the case of the transparent touch panel 14 of the film type which has the lower electrode plate 11B formed of a film with an electrode similar to the upper electrode plate 9, the supporting body may be omitted and the transparent touch panel 14 can be attached directly to the front light unit 15 via the transparent resin layer 12 (referring to Fig. 7). In this constitution, the light guide plate 3 of the front light unit 15 serves also as the supporting body 13 for the lower electrode plate 11B of the transparent touch panel 14, so that the air layer between the supporting body 13 and the light guide plate 3 in the constitution of Fig. 5 is removed. The light transmittance is improved accordingly. The attachment of the transparent touch panel 14 to the light guide plate 3 is easily carried out owing to a soft structure of the transparent touch panel 14 of the film

type.

In each of the embodiments, the external light entering from the side of the uppermost transparent touch panel 14 passes the light guide plate 3 of the front light unit 15 and the reflecting type liquid display panel 5, is reflected at the reflecting plate 6, again passes the reflecting type liquid crystal display 5, the light guide plate 3, and the transparent touch panel 14 to be projected outside. Since the external light passes each part of the display part twice, the light transmittance is considerably decreased in the reflecting type liquid crystal display 5 as compared with the transmission type liquid crystal display. It is therefore important to eliminate two layers, namely, the air layer and the supporting body 13 to improve light transmittance. The air layer has particularly a large difference in index of refraction to the light guide plate 3 and the lower electrode plate 11A, 11B, with inducing a great loss of light as a result of the reflection at an interface of the air layer to the other layer.

For instance, when a transparent acryl plate is used as the transparent light guide plate, a loss of nearly 7% light transmittance results from the surface reflection because of a difference in index of refraction between the acryl plate and the air layer. Thus, saving the air layer

has a good effect on improvement of the light transmittance. In the above example, the 7% loss can be reduced.

The above-referred front light unit 15 will be described next.

The arrangement that the light guide plate 3 is superposed on the reflecting type liquid crystal display 5 requires the light guide plate 3 to exhibit sufficient light transmission efficiency without obstructing visibility of the liquid crystal display.

A thin rectangular plate formed of transparent resin may be used as the light guide plate 3. The transparent resin is resin having superior transparency and light guide performance, such as acrylonitrile-styrene copolymer resin, cellulose acetobutylate resin, cellulose propionate resin, polymethyl pentene resin, polycarbonate resin, polystyrene resin, or polyester resin, etc.

In the above-described first embodiment, since the transparent touch panel 14 is placed at the upper part, a parallax is given rise to if a distance between an upper and a lower faces of the light guide plate 3, that is, a distance between a face of the light guide plate at the side of the reflecting type liquid crystal display 5 and the input face of the light guide plate at the side of the transparent touch panel 14 is too large, resulting in a displacement between a display position and an input

position. When a thickness of the light guide plate 3 is set to be as small as 0.3-2.0mm, the distance between the face of the light guide plate 3 at the side of the reflecting type liquid crystal display 5 and the input face of the light guide plate 3 at the side of the transparent touch panel 14 is maintained to be not larger than 3.0mm. The thickness is preferably 0.3-1.5mm. When the thickness of the light guide plate 3 is smaller than 0.3mm, the light guide plate 3 is difficult to process and a sufficient quantity of light cannot be taken from an end face part of the light guide plate 3 where the light source 4 is located. When the thickness exceeds 2.0mm, the front light unit 15 is increased in thickness and weight to lose portability. The light guide plate 3 can be formed in a wedge-like shape or the like shape in addition to a flat plate of uniform thickness.

In the case where both upper and lower faces of the light guide plate 3 are made in a state of a mirror face, the incident light is sent to an end face opposite to an incident end face of the light guide plate 3 while repeatedly totally reflected at both faces. As a result, hardly any light is projected to the front, i.e., incident end face and, the opposite end face. For solving this, the light diffusion layer 8 is set at least at one face of the light guide plate 3 at the side of the reflecting type

liquid crystal display 5 or the display face, so that the light in the light guide plate 3 is let out towards the reflecting type liquid crystal display 5. When the thus-constituted light guide plate 3 having the diffusion layer 8 is overlapped on the reflecting type liquid crystal display 5, the reflecting type liquid crystal display 5 is illuminated sufficiently. The light from the light source 4 proceeds to the end face opposite to the incident end face of the light guide plate 3 while experiencing repeated total reflection in the light guide plate 3, with illuminating the entire reflecting type liquid crystal display 5.

The light diffusion layer 8 of the light guide plate 3 is required to have sufficient light transmission efficiency for use with external light and not to obstruct visibility of the liquid crystal display. Therefore, the light diffusion layer 8 is adapted to assume a fine shape, specifically, a gradational pattern, a grained form, a prism shape, etc.

A dot gradation formed by screen printing is generally employed for the light diffusion layer 8 at the back light. The dot gradation in this case has a dot diameter of not smaller than 300μm and a pigment is added to enhance the light diffusion performance. If the thus-formed light diffusion layer 8 is to be used directly as it

is as the front light unit 15, the liquid crystal display part 7 is occupied with a high ratio of dots and deteriorated in visibility both when used with external light and when the front light unit 15 is turned on.

Then, according to the fifth embodiment of the present invention, the light diffusion layer 8 of the front light unit used in the front light-combined touch panel device is devised specifically as will be described below. For example, a dot gradation pattern is formed with the use of an ink having, as the main ingredient, a transparent or semitransparent resin of a higher index of refraction than the light guide plate 3 to the face of the light guide plate 3 at the side of the reflecting type liquid crystal display 5, thereby constituting a light diffusion layer 8A. The other face of the light guide plate 3 at the side of the display face is made a mirror face (referring to Fig. 8). A diameter of each dot in dot gradation of the light diffusion layer 8A is set to be not larger than 200μm and an area ratio of the dots is not larger than 60%, whereby the visibility of the reflecting type liquid crystal display 5 is increased. The light entering the interior of the light guide plate 3 is, repeating the total reflection inside, sent to the end face opposite to the incident end face of the light guide plate 3. The light is further projected from the dots of the light diffusion layer 8A

formed at the side of the reflecting type liquid crystal display 5 of the light guide plate 3, thus illuminating the reflecting type liquid crystal display 5. The quantity of light to be projected at the light diffusion layer 8A can be adjusted through an adjustment of a gradation ratio of the light diffusion layer 8A, and accordingly the reflecting type liquid crystal display 5 can be illuminated uniformly.

In a front light unit used in a front light-combined touch panel device according to the sixth embodiment of the present invention, the dot gradation pattern may be formed to the face of the light guide plate 3 at the side of the display face, with the same dot diameter and the same area ratio as above with the use of an ink having, as the main ingredient, a transparent or semitransparent resin of a higher index of refraction than the light guide plate 3 and including a light diffusible pigment, thereby constituting a light diffusion layer 8B (referring to Fig. 9). In this case, the light entering the light guide plate 3 is irregularly reflected and diffused by dots of the light diffusion layer 8B formed at the side of the display face of the light guide plate 3, and projected to the face at the side of the reflecting type liquid crystal display 5, thereby illuminating the reflecting type liquid crystal display 5. Because of the

diffusible pigment mixed in the ink of the light diffusion layer 8B, the light is more efficiently projected. The quantity of light to be projected at the light diffusion layer 8B is adjustable by adjusting the gradation ratio of the layer 8B, so that the reflecting type liquid crystal display 5 is illuminated uniformly.

Gravure printing, screen printing, or the like printing method is usable to form the above dot gradation pattern. A method of transferring simultaneously with molding is preferred because the dot gradation pattern can be formed simultaneously when the light guide plate 3 is molded. The method of transferring simultaneously with molding is specifically such that a transfer material having a transfer layer formed on a base sheet is held in a mold, a resin is injected to fill the mold and then cooled, thereby obtaining a resin mold and bonding the transfer material to a surface of the mold at the same time, then the base sheet is separated, whereby the transfer layer is transferred to a subject face to be transferred.

A front light unit in a front light-combined touch panel device according to a seventh embodiment of the present invention may be provided with a light diffusion layer 8D at the face of the light guide plate 3 at the side of the display face in a fine grained form of a degree not to attenuate the display visibility considerably (referring

to Fig. 10). The grained form of the light diffusion layer 8D of the light guide plate 3 is obtained by forming a grained form to an inner face of the mold and producing the grained form when the light guide plate 3 is molded. Alternatively, the surface of the light guide plate 3 may be subjected to fine matting process of a diameter of approximately 30μm to form the light diffusion layer 8D. The light entering from the end face of the light guide plate 3 is scattered inside the light guide plate 3 because of the grained or mat form of the light diffusion layer 8D, and part of the light is projected to the reflecting type liquid crystal display 5.

A plurality of prisms may be formed as a light diffusion layer 8E at the face of the light guide plate 3 at the side of the reflecting type liquid crystal display 5 to be in parallel to the incident end face of the light guide plate 3, as in a front light unit of a front light-combined touch panel device according to an eighth embodiment of the present invention (referring to Fig. 11). The light incident upon the light guide plate 3 illuminates the reflecting type liquid crystal display 5 through a prism face of the light diffusion layer 8E. The prism of the light diffusion layer 8E is, e.g., a regular triangle, a lens shape, etc. A size or a pitch of prisms of the light diffusion layer 8E is changed in proportion to a

distance from the incident end face, thereby controlling to balance outputs of the light diffusion layer 8E. The prisms of the light diffusion layer 8E are preferably formed with a pitch of 30-500μm and a breadth of 30-100μm in order not to adversely influence the visibility.

According to each of the embodiments of the present invention, the light diffusion layer 8 can be formed of a transparent or semitransparent resin of a higher index of refraction than that of the light guide plate 3.

Concretely, a front light unit in a front light-combined touch panel device in a ninth embodiment of the present invention may be provided with a light diffusion layer 8C of the transparent resin of a higher index of refraction than the light guide plate 3 at the side of the display face of the light guide plate 3 (referring to Fig. 12). The light entering the light guide plate 3 is reflected at an interface of the light guide plate 3 to the light diffusion layer 8C because of a difference in index of refraction therebetween, further projected to the air layer and eventually illuminates the reflecting type liquid crystal display 5. In the constitution, since dots, etc. are not present at the front face of the light guide plate 3, the visibility of the reflecting type liquid crystal display 5 is hardly influenced.

The light source 4 is disposed at an end face of the light guide plate 3. The light source 4 is arranged at least at one side of the rectangular light guide plate 3. A cold cathode fluorescent tube, an LED or the like is employable as the light source 4.

The cathode ray tube to be used is a straight one, an L-shaped tube astride adjacent two side faces, a U-shaped tube extended to adjacent three side faces, etc.

As shown in Figs. 4-7, a reflector 49 may be installed so as to efficiently condense the light projected from the light source 4 to the incident end face of the light guide plate 3. The reflector 49 is preferably obtained by a metallic plate having a surface of material specularly reflecting light, for example, a member having a surface coated with silver, aluminum, platinum, nickel, or chromium, particularly, silver, aluminum, or the like by vapor deposition or sputtering. The light diffusible reflecting plate 6 or light diffusible film having light diffusion properties applied by blending polyester or the like resin with a light diffusible substance such as $TiO_2$, $BaSO_4$ or $SiO_4$, or by foaming polyester or the like resin is also utilizable.

As described hereinabove, since the front light unit 15 and the transparent touch panel 14 are combined in one body via the transparent resin layer 12, the

transmittance is improved. The supporting body 13 is eliminated when the transparent touch panel 14 of the film type is used, whereby the device is furthermore simplified and improved in transmittance.

Next, there is provided a front light unit of a front light-combined touch panel device according to the tenth embodiment of the present invention which can sufficiently illuminate a reflecting type liquid crystal display without lowering transmittance, with eliminating the following inconvenience.

That is, it is necessary to illuminate the reflecting type liquid crystal display from the front side when in use in an environment where a sufficient quantity of light is not secured, e.g., indoors or at night, etc. To this, an arrangement is proposed whereby a flat illumination (front light) is set at a front face of the reflecting type liquid crystal display, thereby using both an environment light and the front light (for instance, SID, 95 Digest, page 375, C.Y. Tai, H. Zou, P.K. Tai). The front light has a light source 104 such as a cold cathode fluorescent tube or the like set at an end face of a light guide plate 103 of transparent resin or the like, along with prisms or the like minute projections and dips 108 formed on a front face of the light guide plate 103 (referring to Fig. 13). Light beams taken from an end face

part of the light guide plate 103 are guided inward while repeating total reflection inside the light guide plate 103. Part of the light beams is reflected by the projections and dips 108 with an angle whereby the beams are easy to project to the side of the reflecting type liquid crystal display of the light guide plate 103, and projected out from the light guide plate 103, thereby illuminating the reflecting type liquid crystal display.

In many of the conventional portable electronic apparatuses, a transparent touch panel is disposed at a front face of a transmission type liquid crystal display to provide an input function from a liquid crystal display face. The transparent touch panel includes an upper electrode sheet 109 having an upper electrode of a transparent conductive film at a lower face of a film-like insulating substrate and a lower electrode sheet 111 having a lower electrode of a transparent conductive film at an upper face of a sheet-like or film-like insulating substrate. The upper electrode sheet 109 and lower electrode sheet 111 are arranged to face each other via an air layer between the electrodes. To press part of a panel surface from an input face brings both electrodes into touch and electric connection with each other, thereby enabling inputs. In a proposal (for example, Japanese Laid-Open Patent Publication No. 61-131314), the touch

panel is bonded to the transmission type liquid crystal display via a self-adhesive layer or re-release sheet, because the air layer if present even slightly between the transparent touch panel and the transmission type liquid crystal display causes a surface reflection at an interface and deteriorates transmittance of the device.

On the other hand, the touch panel of the above-described constitution cannot be bonded to a reflecting type liquid crystal display using the front light as an illumination source. Since the minute projections and dips 108 of the light guide plate 103 of the front light are designed to project part of the light beams taken from an end face of the light guide plate 103 to the reflecting type liquid crystal display with the utilization of a reflection at the interface to the air layer, an elimination of the air layer through the attachment of the touch panel to a front face of the light guide plate of the front light disenables the minute projections and dips 108 to project light beams to the reflecting type liquid crystal display (referring to Fig. 14).

For solving this inconveniences, the front light unit of the front light-combined touch panel device according to the tenth embodiment of the present invention is constructed as follows.

The light guide plate 3 can be such that has no

minute projections and dips 58 at the upper face as shown in Fig. 15. One from which the air layer can be removed by the attachment to the transparent touch panel 14 is also utilizable as the light guide plate 3 even if the minute projections and dips 58 are present. In any case, light beams taken from the end face part to reach the front face of the light guide plate 3 are brought into the transparent touch panel 43 via the transparent resin layer 12 or re-release sheet. Most of the light beams entering the transparent touch panel 14 are totally reflected at the front face of the lower electrode sheet 11, i.e., at an interface between the lower electrode and the air layer. The light beams are sent to an end face opposite to the incident end face of the light guide plate 3 while repeating the total reflection at the interface and a total reflection at a rear face of the light guide plate 3. In the meantime, a part of the light beams entering the transparent touch panel 14 is reflected not totally at the interface between the lower electrode formed on the insulating substrate of the lower electrode sheet 11 and the air layer, because the insulating substrate of the lower electrode sheet 11 is provided with the minute projections and dips 58 at the upper face, and the interface between the lower electrode and the air layer is shaped in minute projections and dips accordingly. A part

of the light beams is reflected instead with an angle whereby the beams are easy to project to the reflecting type liquid crystal display (referring to Fig. 15). The thus-constituted front light-combined touch panel is superposed on the reflecting type liquid crystal display 5, whereby the reflecting type liquid crystal display 5 is illuminated sufficiently.

The dent part of the minute projections and dips 58 can be constructed by many minute dips formed at the entire upper face of the insulating substrate of the lower electrode sheet 11. The minute dips are formed in an optional shape enabling the light beams to be reflected with the angle easy for the light beams to project to the reflecting type liquid crystal display, for example, in a recessed conical or mortar shape, etc. The minute dips are obtained by processing a surface of the insulating substrate with heat and pressure by concave and convex rolls when or after the insulating substrate is molded, or by forming a shape corresponding to the minute dips to a cavity face defined by a mold inner wall or shaping sheet thereby transferring the shape when the insulating substrate is a resin plate molded in a mold, or the like manner. The dips are preferably of a diameter of 5-40μm to exert sufficient light transmission efficiency when the touch panel is used with the external light and to prevent

attenuation of visibility of the liquid crystal display part 7.

Preferably, an area ratio of the minute dips in the vicinity of the light source 4 is set to be smaller than an area ratio of the minute dips away from the light source 4. The area ratio is changed by changing a size, a pitch of the dips in accordance with a distance from the light source 4. Thus, the projection of light from the minute projections and dips 58 is controlled to balance, achieving uniform illumination to the reflecting type liquid crystal display 5.

The film-like insulating substrate having the minute projections and dips 58 can be provided with many minute projections by incorporating transparent fine beads before molding the film-like insulating substrate. The beads are formed of a material similar to that of the insulating substrate or a resin of a small difference in index of refraction to the insulating substrate in order to maintain a level of transmittance of the insulating substrate itself. The beads present on the film surface may be coated completely with a resin constituting the film or may be partly exposed. A diameter of the beads is preferably 5-40μm to secure sufficient light transmission efficiency in use with the external light and not to worsen visibility of the liquid crystal display part 7.

The projections of the minute projections and dips 58 can be formed in a coat by coating or printing of an ink including transparent minute beads. The beads are formed of a material similar to that of the insulating substrate or a resin or glass showing a small difference in index of refraction to the insulating substrate to keep a level of transmittance of the insulating substrate itself. The beads on the coat surface can be coated totally with the coat or exposed partly from the coat. The bead is preferably 5-40μm in diameter to attain sufficient light transmission performance in use with the external light and avoid deterioration of visibility of the liquid display part 7.

The coat of the ink including transparent beads is preferably formed in a dot gradation pattern having a larger area ratio at points away from the light source 4 than in the vicinity of the light source 4. A size, a pitch of dots is changed in accordance with a distance from the light source 4 so as to change the area ratio of the coat. Light projection at the minute projections and dips 58 is thus controlled to balance, so that the reflecting type liquid crystal display 5 is illuminated uniformly. Gravure printing, screen printing, or the like printing method can be used to form the gradation pattern. A shape of the dots is not particularly limited and any shape such

as a circle, a polygon, etc. is adoptable.

In the eleventh embodiment, as shown in Fig. 16, the light guide plate 33 which is made of acryl as an example is provided with flat parts 33a having faces in parallel to the other face at the side of the touch panel and inclined parts 33b having mutually parallel faces inclined to the other face alternately arranged at one face thereof at the side of the liquid crystal display 5. The incident face of the light guide plate 33 is at right angles to the other face. The light beams entering from the side end face are totally reflected at the other face confronting the touch panel of the light guide plate 33 and at the flat parts 33a parallel to the other face on the one face at the side of the liquid crystal display 5 of the light guide plate 33, and projected out only from the inclined parts 33b, thereby illuminating the liquid crystal display 5. The light illuminated on the liquid crystal display 5 is reflected at the reflecting face under the liquid crystal through the liquid crystal, passing the light guide plate 33 and the touch panel again, to be projected outside. Accordingly, the liquid crystal display of a device using the reflecting type liquid crystal panel can be recognized even in an environment without a sufficient quantity of light.

Figs. 17 and 18 indicate examples of the flat

parts 33a parallel to the other face and the inclined parts 33b inclined to the other face at the one face of the light guide plate 33 at the side of the liquid crystal panel of Fig. 16.

The angle α between the flat part 33a and the inclined part 33b in Fig. 17 is 90°. In this case, the incident light reaching the inclined part 33b assumes the same angle as the incident face, and therefore is totally projected outside of the light guide plate 33.

In Fig. 18, the angle α of the parts 33a and 33b is set to be greater than 90° and less than 180°. Supposing that a height from a flat plane of the inclined part 33b, i.e. a thickness t of the inclined part 33b is equal in Figs. 17 and 18, an area of the inclined part 33b in Fig. 18 is larger, so that a larger quantity of light can be projected from each inclined part 33b in Fig. 18 than in Fig. 17.

Preferably, an angle defined between the end face where the light source 4 of the light guide plate 33 is disposed and a face of the light guide plate 33 at the side of the touch panel is 88-92°, and an angle defined between the flat face of the flat part 33a and the inclined face of the inclined part 33b adjacent to the flat part 33a in an opposite direction to an incident face of the light guide plate 33 on the face at the side of the liquid crystal

display 5 is not smaller than the above angle and smaller than 180°.

In molding or cutting the light guide plate 33, however, an angle of the incident face to the other face at the side of the touch panel is not always correctly 90° because of process accuracy. The angle accuracy is within ±2° in the molding or cutting technique at present. With the angle taken into account, an angle of incidence of light to the side face as the incident face is required to be not larger than 44° so as to totally reflect the light entering from the incident face at the other face confronting the touch panel of the light guide plate 33 and the flat parts 33a at the one face of the light guide plate 33 at the side of the liquid crystal panel. The index of refraction of the light guide plate 33 at this time is not smaller than 1.44.

In order to project the incident light from the inclined parts 33b, an angle α of the flat part 33a having the faces parallel to the other face confronting the touch panel which is located on the other face of the light guide plate 33 confronting the liquid crystal display 5 to the inclined part 33b adjacent to the above flat part 33a in an opposite direction to the incident face is required to be 90-180°. When the angle is 90°, the inclined part 33b becomes parallel to the side face as the incident face.

Although a distance between the flat part 33a and inclined part 33b continuous at the one face of the light guide plate 33 at the side of the liquid crystal display 5 is made uniform, the distance can be changed to even the emission in accordance with a position of the light source 4.

As one modification of the eleventh embodiment, a reflection reduction treatment to the one face of the light guide plate 33 at the side of the liquid crystal display 5 improves transmittance of the whole of the front light-combined touch panel device.

In a way of the reflection reduction treatment, a transparent layer 34 of a lower index of refraction than the light guide plate 33 is formed at the one face of the light guide plate 33 at the side of the liquid crystal display, for example, by directly processing and forming a film of a substance of low index of refraction to the resin surface of the light guide plate 33. When an inorganic substance such as $MgF_2$ (index of refraction of 1.38) or the like metal fluoride, $SiO_2$ (index of refraction of 1.46) or the like metallic oxide is used, vacuum vapor deposition, etc. can be used. When an organic substance is used, fluoric monomers are plasma-polymerized, thereby forming the transparent layer 34 of a film to the resin surface. Dip coating or the like method may be employed as well for

the organic substance.

Alternatively, a film having a transparent layer 34 of a lower index of refraction than the light guide plate 33 is bonded to the one face of the light guide plate 33 at the side of the liquid crystal display 5 with the use of a transparent self-adhesive having an index of refraction equal to or not larger than that of the light guide plate and equal to or not smaller than that of the film, thereby constituting the low refraction index layer 34 to the interface to the air layer.

Specifically, referring to Fig. 19, the light guide plate 33 is provided with a transparent layer 34 at the one face thereof confronting the liquid crystal display 5. The transparent layer 34 has an index of refraction smaller than that of the light guide plate 33 and larger than that of the air layer. The light guide plate 33 is formed of acrylic resin, and the transparent layer 34 is formed by dip coating of fluoric monomers. The surface reflection at the other face of the light guide plate 33 caused by the presence of the interface to the air layer leads to a decrease of transmittance. Therefore, the resin layer 34 is arranged to effect the reflection reduction treatment, thereby reducing reflectance at the interface and improving transmittance.

Such a transparent layer 34 can be applied to

each light guide plate 3 in the previous embodiments to obtain the same effect.

According to the constitution, since the air layer present conventionally between the touch panel and light guide body in a device with the touch panel and front light incorporated therein is eliminated, the loss of light due to the reflection at the interface between the air layer and the lower face of the touch panel and between the air layer and the upper face of the light guide plate is prevented, thereby enhancing the transmittance of the whole device. Moreover, since the lower electrode sheet of the touch panel is equipped with the light-diffusing function face at the interface to the air layer, the light is emitted efficiently from the front light.

As described hereinabove, in the constitution of the portable electronic apparatus which has the reflecting type liquid crystal display as a display part, with the front light and the touch panel loaded at the display part, wherein the lower face of the transparent touch panel and the upper face of the light guide plate of the front light are bonded via the transparent self-adhesive layer, the light-diffusing function conventionally provided at the surface of the light guide plate is achieved at the one face of the light guide plate of the front light at the side of the liquid crystal unit, so that the transmittance

of the whole apparatus is improved. The front light efficiently projects light without losing visibility when in use under daylight.

[Example 1]

A polyethylene terephthalate film having a matt resin incorporated therein thereby forming a fine pattern of projections and dips on a surface thereof is fixedly held in an injection molding mold. After the mold is clamped, a transparent acrylic resin is injected therein. The polyethylene terephthalate film is separated from a molded article after the mold is opened.

In this manner, a rectangular transparent acryl plate of a thickness of 1.5mm is obtained as the light guide plate. The light guide plate has a light diffusion layer where approximately 30μm fine projections and dips are formed irregularly at one face thereof. Another face of the light guide plate is a mirror face.

A cold cathode fluorescent tube of a diameter of 2mm is arranged as a line light source at one of longer sides of the light guide plate. A reflecting film having a silver vapor-deposition face at the side of the cold cathode fluorescent tube is set as the reflector in the circumference of the cold cathode fluorescent tube not faced to the light guide plate. Moreover, a reflecting film of white foamed polyethylene terephthalate is attached

via a pressure sensitive adhesive double-coated tape to an end face of the light guide plate opposite to an incident end face.

A glass substrate having an ITO (Indium Tin Oxide) conductive film at a surface thereof is used as the lower electrode plate, and a polyethylene terephthalate film having an ITO conductive film at a surface thereof is used as the upper electrode plate of the transparent touch panel. An upper face of the light guide plate is attached to the lower side of the touch panel via a transparent adhesive gel of acrylic resin having a thickness of 0.2mm as the transparent resin layer.

The front light-combined touch panel device constituted as above is set in parallel to the liquid crystal panel above the liquid crystal panel. The light diffusion layer of the light guide plate is arranged at the side opposite to the liquid crystal panel, and the reflecting plate is placed below the liquid crystal panel.

The light brought from the light source into the light guide plate is partly scattered by the fine matt form and projected to the liquid crystal panel, thereby being projected to the liquid crystal panel and then illuminating the liquid crystal panel. The illuminated light passing through the liquid crystal layer is reflected at the reflecting plate below the liquid crystal panel, passes

through the liquid crystal layer again, and further through the light guide plate to be projected outside.

In the above constitution, the liquid crystal display part has sufficient visibility both when the front light unit is turned on and when the front light unit is turned off.

[Example 2]

The light guide plate is constituted in the same manner as the Example 1.

The lower electrode plate and the upper electrode plate of the transparent touch panel are both formed of a polyethylene terephthalate film having an ITO conductive film at respective surfaces. An upper face of the light guide plate is attached to the lower side of the transparent touch panel via a transparent adhesive layer of acrylic resin having a thickness of 50μm as the transparent resin layer. The light guide plate of the front light unit in the constitution works also to support the transparent touch panel.

The liquid crystal display part of the obtained front light-combined touch panel device shows sufficient visibility both when the front light unit is turned on and when the front light unit is turned off. Since a supporting body generally required to support the transparent touch panel of the film type is eliminated

because the light guide plate of the front light unit works as the supporting body, the constitution is simplified. Moreover, a reduction in parts count contributes to improvement in transmittance.

The present invention is constituted as discussed hereinabove and accordingly operates as follows.

In the front light-combined touch panel device according to the present invention, on the reflecting plate are sequentially layered the reflecting type liquid crystal display, the front light unit including the transparent 0.3-2.0mm thick light guide plate and the light source set at the end face of the light guide plate, and the transparent touch panel. The front light unit is reduced in thickness and therefore does not increase a size or weight of a portable electronic apparatus, thus not deteriorating portability of the portable electronic apparatus. Since the light source is accommodated in a main body of the portable electronic apparatus, the light source is never lack of protection.

The front light unit is set in a state while overlapped with the reflecting type liquid crystal display. The front light unit is accordingly protected from a break during use. A storing mechanism for storing the front light unit when not used is eliminated.

Although the present invention has been fully

described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.

CLAIMS

1. A front light-combined touch panel device comprising: a reflecting type liquid crystal display (5); a front light unit (15) including a transparent light guide plate (3) and a light source (4) set at an end face of the light guide plate; and a transparent touch panel (14), which are sequentially layered on a reflecting plate (6).

2. A front light-combined touch panel device according to Claim 1, wherein the transparent touch panel (14) is a transparent touch panel of a resistive model, with having an upper part of the front light unit bonded to a lower part of the transparent touch panel via a transparent resin layer (12).

3. A front light-combined touch panel device according to Claim 1, wherein the transparent touch panel (14) is a transparent touch panel of a film type of a resistive model, with having an upper part of the front light unit bonded to a lower part of the transparent touch panel via a transparent resin layer (12).

4. A front light-combined touch panel device according to any one of Claims 1-3, wherein the light guide plate (3) has a minute polygonal or circular dot gradation pattern formed at least at one face thereof of a dot size of 200μm or smaller and an area ratio of 60% or smaller with the use of an ink having, as a most ingredient, a

transparent or semitransparent resin of a higher index of refraction than the light guide plate.

5. A front light-combined touch panel device according to Claim 4, wherein the light guide plate (3) has the dot gradation pattern formed with the use of an ink having, as a most ingredient, a transparent or semitransparent resin of a higher index of refraction than the light guide plate and including a light diffusible pigment.

6. A front light-combined touch panel device according to any one of Claims 1-3, wherein the light guide plate (3) is constituted of a transparent or semitransparent resin layer of a higher index of refraction than the light guide plate at least at one face thereof.

7. A front light-combined touch panel device according to any one of Claims 1-6, wherein the light guide plate (3) has a fine grained pattern formed at least at one face thereof.

8. A front light-combined touch panel device according to any one of Claims 1-6, wherein the light guide plate (3) has a plurality of prisms formed at least at one face thereof at the side of the reflecting type liquid crystal display with a pitch of 30-500μm and a breadth of 30-100μm in parallel to an incident end face thereof.

9. A front light-combined transparent touch panel

device according to any one of Claims 1-8,

wherein the transparent touch panel comprises: an upper electrode sheet having an upper electrode formed on a lower face of a film-like insulating substrate; and a lower electrode sheet having a lower electrode formed on an upper face of a plate-like or film-like insulating substrate with minute projections and dips arranged on the upper face thereof, in which the upper electrode sheet and the lower electrode sheet are arranged to face each other via an air layer between the electrodes, and

wherein the light guide plate bonded to a rear face of the transparent touch panel via a transparent resin layer, and the transparent touch panel and the front light unit are combined in one body.

10. A front light-combined transparent touch panel device according to Claim 9, wherein a dent part of the minute projections and dips is constituted of many minute dips on the entire upper face of the insulating substrate.

11. A front light-combined transparent touch panel device according to Claim 10, wherein an area ratio of the minute dips distanced away from the light source is larger than an area ratio of the minute dips in a vicinity of the light source.

12. A front light-combined transparent touch panel device according to any one of Claims 9-11, wherein the

film-like insulating substrate with the minute projections and dips has many minute projections formed by transparent minute beads incorporated in resin to be molded, before the film-like insulating substrate is molded.

13. A front light-combined transparent touch panel device according to any one of Claims 9-11, wherein the projections of the minute projections and dips are formed in a coat by coating or printing of an ink including transparent minute beads.

14. A front light-combined transparent touch panel device according to Claim 13, wherein the coat is formed in a dot gradation pattern having a larger area ratio at a part away from the light source than in a vicinity of the light source.

15. A front light-combined touch panel device according to any one of Claims 1-14, wherein the light guide plate comprising: a flat face at a side of the touch panel; and at a side of the liquid crystal display, a flat part (33a) having a flat face at a side of the liquid crystal display and an inclined part (33b) having an inclined face at a side of the liquid crystal display, and light entering from a side face of the light guide plate is reflected on the flat face of the flat part, inside of the light guide plate, and the light is projected outside from the inclined face of the inclined part.

16. A front light-combined touch panel device according to Claim 15, wherein an angle defined between the end face where the light source of the light guide plate is disposed and a face of the light guide plate at the side of the touch panel is 88-92°, and an angle defined between the flat face of the flat part and the inclined face of the inclined part adjacent to the flat part in an opposite direction to an incident face of the light guide plate on the face at the side of the liquid crystal display is not smaller than the above angle and smaller than 180°.

17. A front light-combined touch panel device according to any one of Claims 1-16, further comprising a transparent layer (34) of a smaller index of refraction than the light guide plate is formed at the face of the light guide plate at the side of the liquid crystal display.

18. A front light-combined touch panel device according to any one of Claims 1-17, wherein the light guide plate has a 0.3-2.0mm thickness.

Fig.1

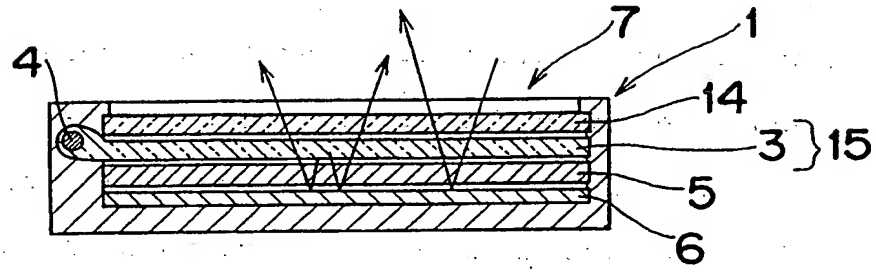



Fig.2

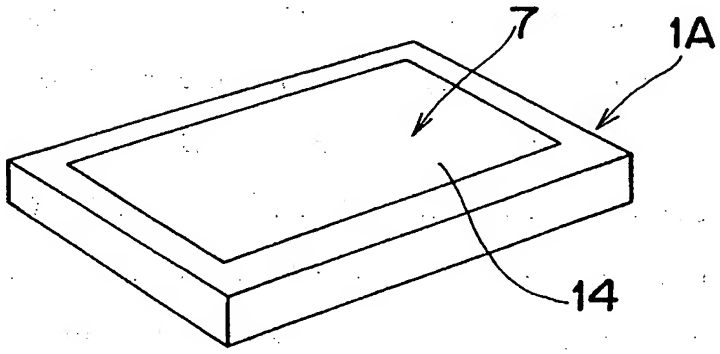



Fig.3

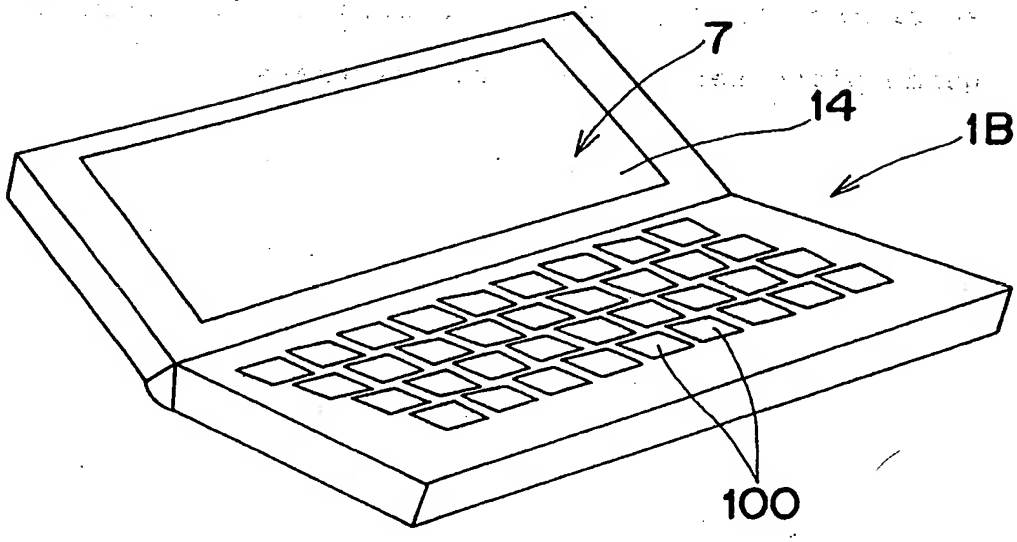


Fig.4

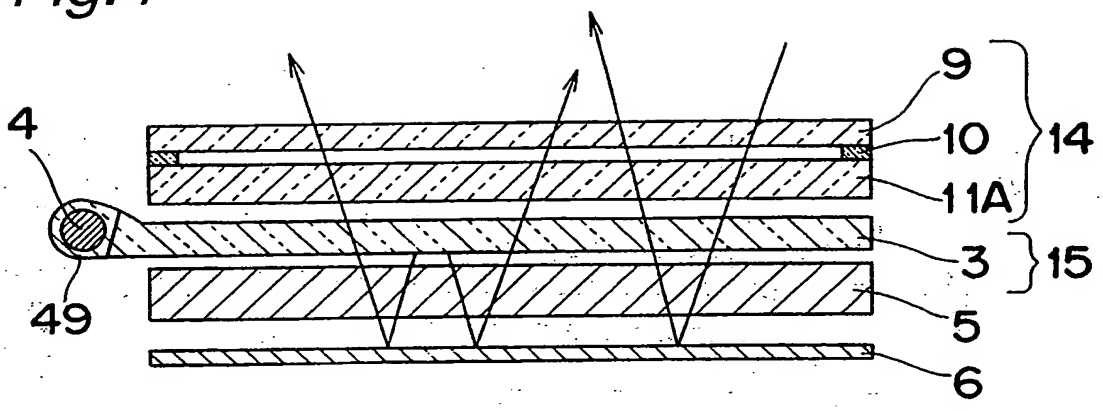



Fig.5

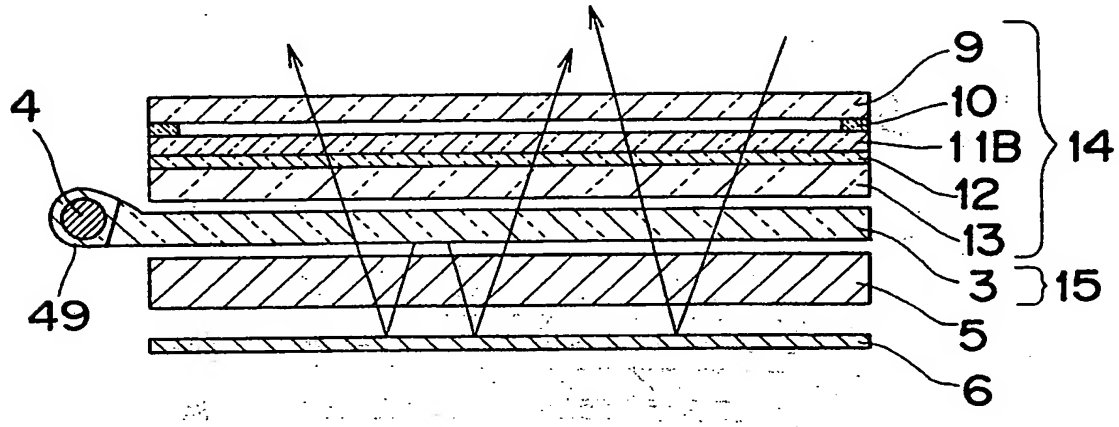



Fig.6

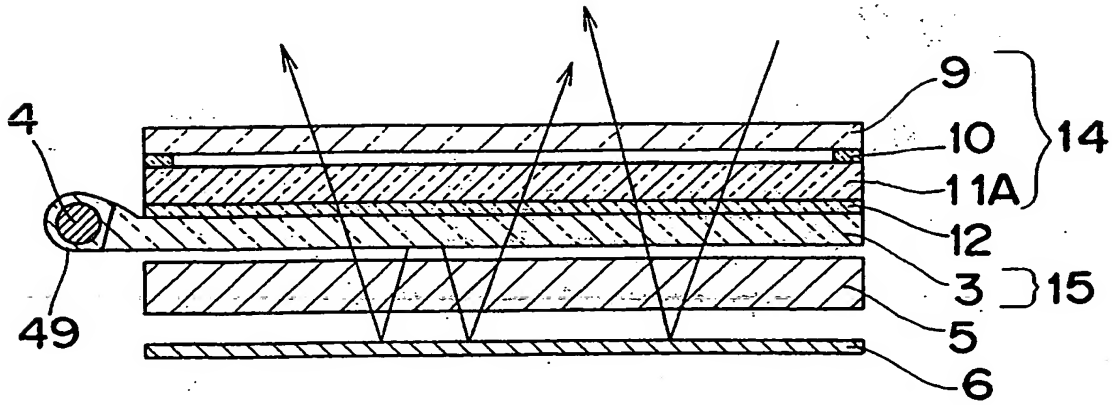


Fig.7

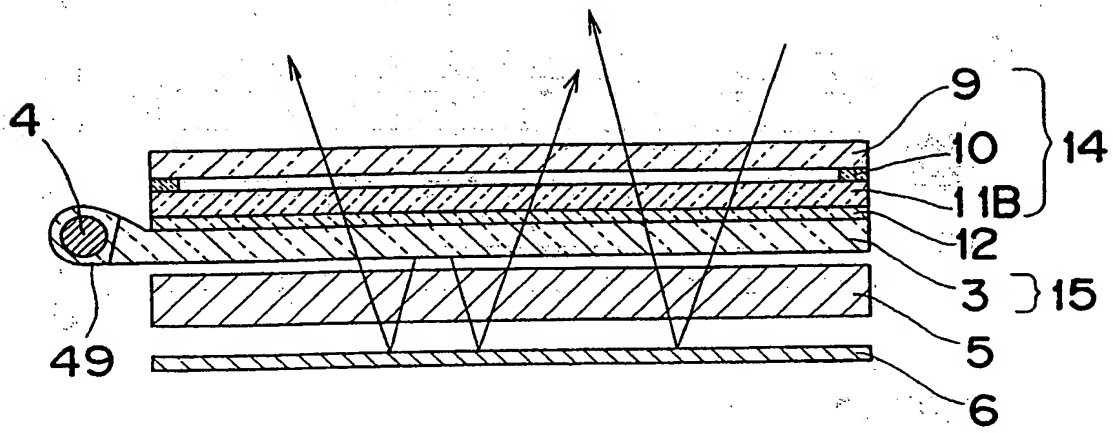



Fig.8

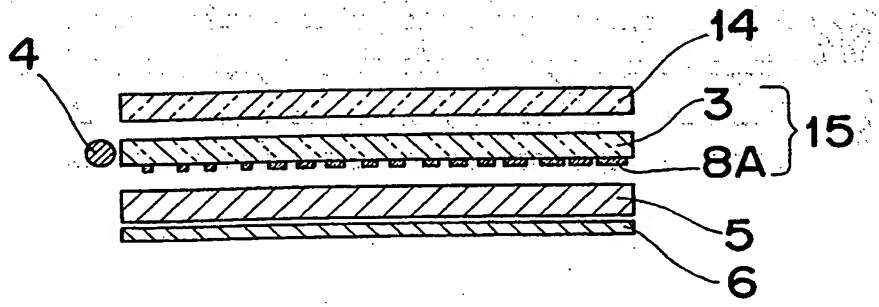



Fig.9

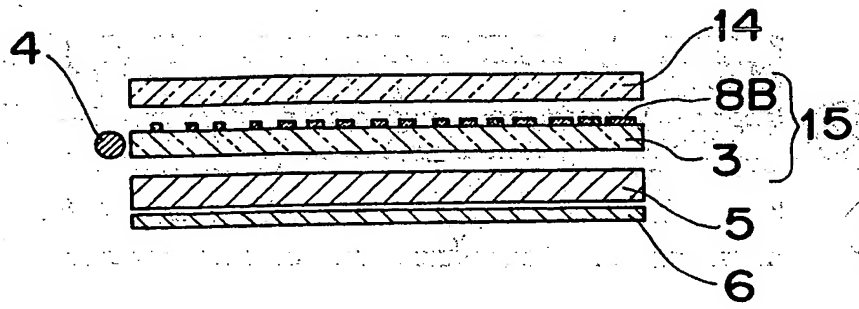


Fig.10

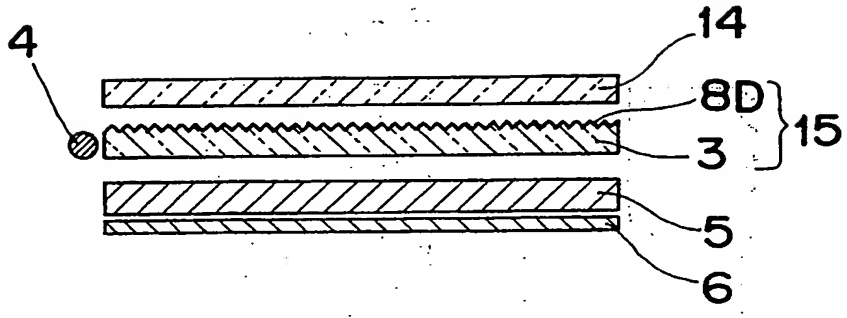



Fig.11

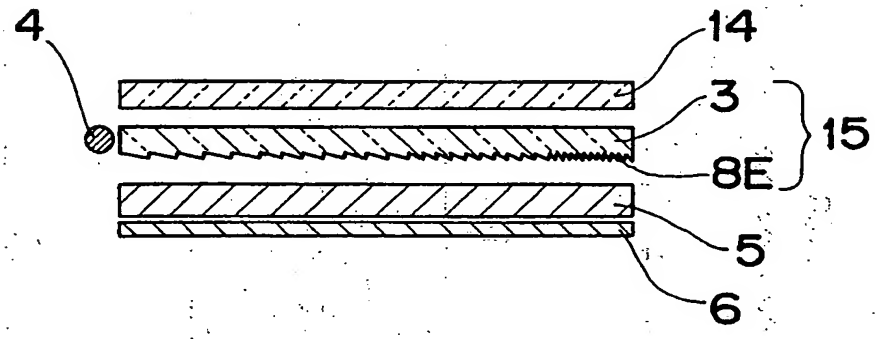
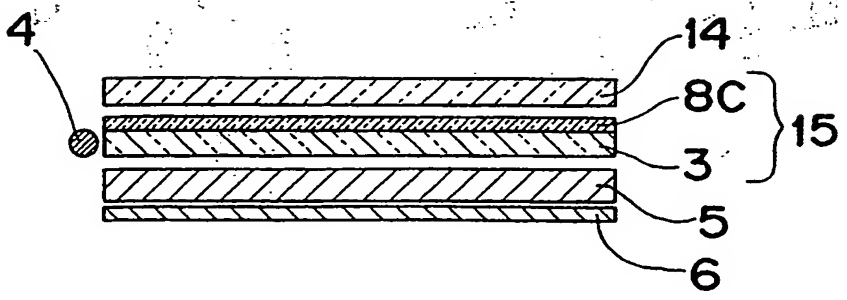



Fig.12



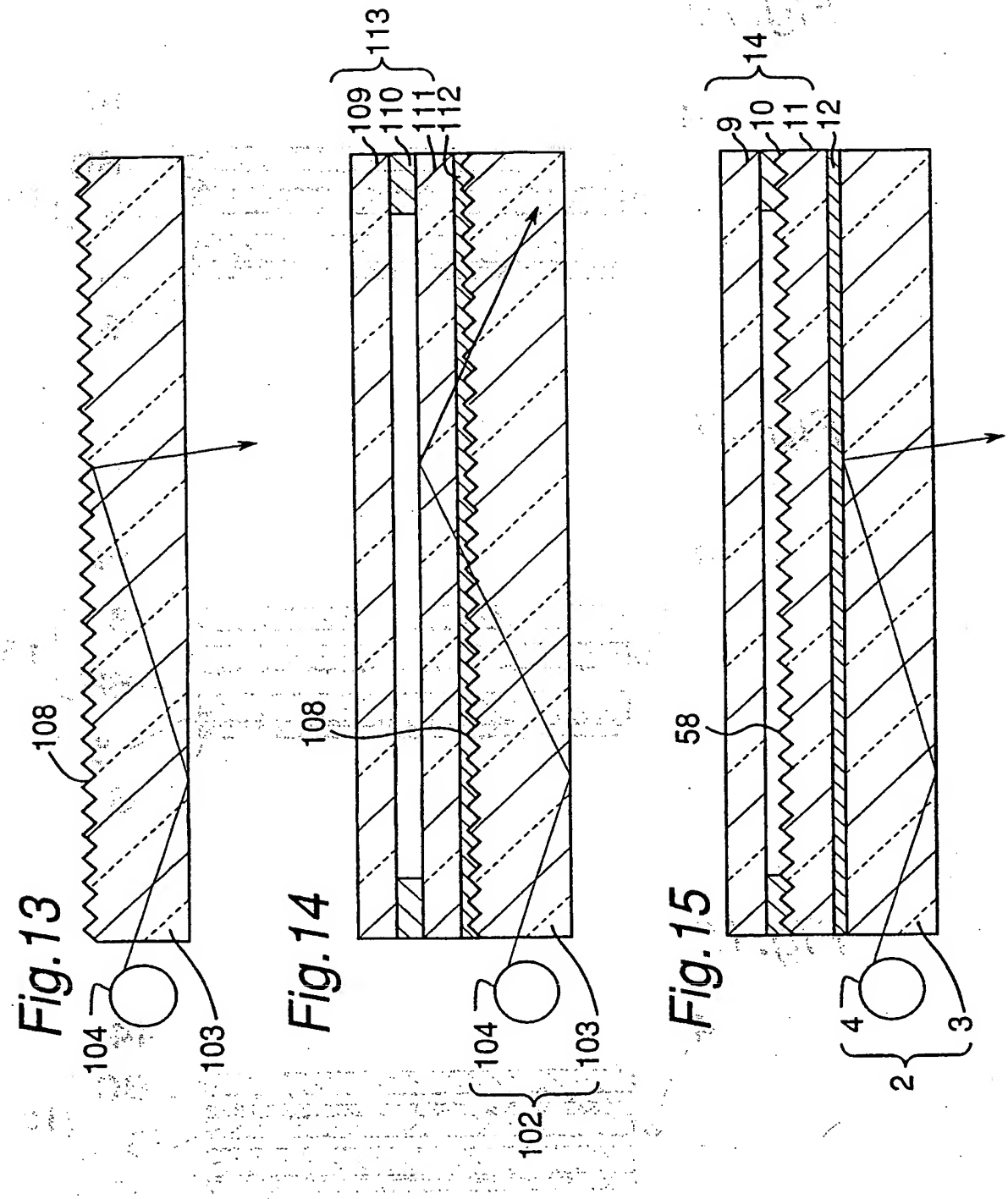



Fig.13

Fig.14

Fig.15

Fig.16

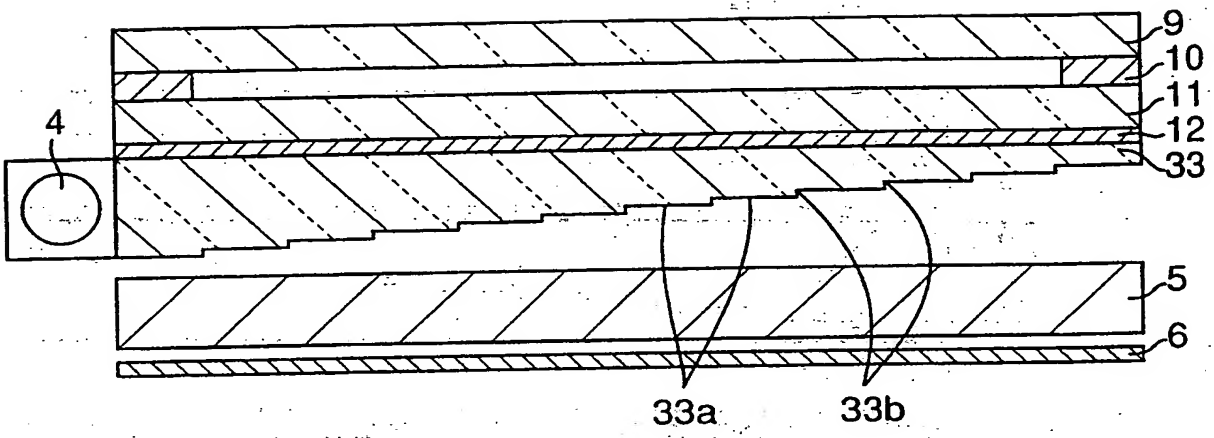



Fig.17

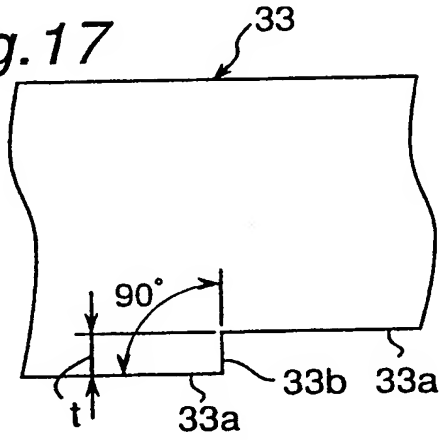



Fig.18

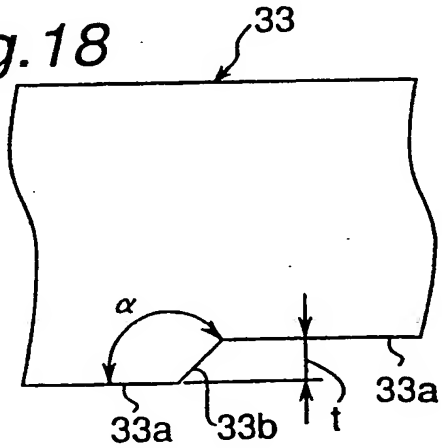
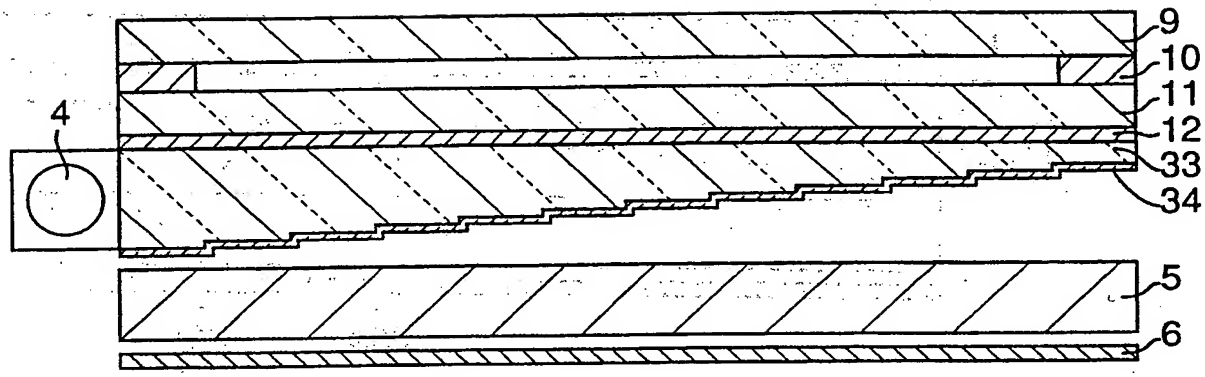


Fig.19



# INTERNATIONAL SEARCH REPORT

International Application No
PCT/JP 99/02916

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G02F1/1335

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G02F G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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| Y | PATENT ABSTRACTS OF JAPAN<br>vol. 1999, no. 08,<br>30 June 1999 (1999-06-30)<br>& JP 11 065764 A (MATSUSHITA ELECTRIC IND CO LTD), 9 March 1999 (1999-03-09)<br>abstract | 1-3,7 |
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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| Date of the actual completion of the international search | Date of mailing of the international search report |
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| 8 October 1999 | 15/10/1999 |

| Name and mailing address of the ISA | Authorized officer |
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| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | Baldan, M |

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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